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Decline and Conservation of Butterflies in Japan

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Abstract. Japanese lepidopterists so far have not defined their strategies to counter the decline of butterfly fauna in their country, although extinctions have so far been restricted to local populations. National and local government policies are to simply promulgate protective regulations. In most cases this means nothing more than the prohibition of collecting and has proved ineffective in reversing the rapid decline and extinction of butterfly populations. The existence and significance of the Red Data Book, currently in preparation in Japan, is as yet not widely acknowledged. However, a volume of collected papers on the history of the decline and protection of Japanese butterflies has been published by the Lepidopterological Society of Japan. It shows that traditional agriculture and silviculture practices in Japan contributed to the dynamic succession of deciduous and non-deciduous broadleaf forests (the latter being the laurisylvae) and maintenance of various types of open fields and meadows, all much needed habitats for the survival of a butterfly fauna with high biodiversity. In the preagricultural wilderness, this continuing dynamism was probably effected by forest fires, typhoons and floods. Fire, wind, water, and traditional culture historically served as protective agents for butterflies, rather than the formal prohibition of collecting.

Introduction

Japan is an archipelago, situated at the eastern margin of the Palearctic Region, and ranging over 3000 km from subboreal to subtropical climates, which in latitude roughly corresponds to the expanse from Quebec to Cuba or from Como to Aswan. It has 238 resident butterfly species, none of which have yet suffered complete extinction. However, because of the devastating industrialization and recent rapid rise of the "living standard" in Japan, many local butterfly colonies have become extinct. It would therefore be useful to compare aspects of Japanese butterfly survivability with their European counterparts at the other end of the Palearctic Region.

Climatic and vegetational differences from Europe

Situated equally in the Palearctic temperate zone, the European and Japanese butterfly faunas show a remarkable difference in the fact that Japan has a 3- to 5-times higher precipitation than the average in Europe throughout the year, but especially during the Monsoon season (June and July). Hence two-thirds of its quite hilly land remains covered by (mostly secondary) forests even with the recent heavy industrialization. Japan thus faunistically lacks the so-called Mediterranean element, but instead has a Chinese element. The former is characterized by its sclerophyll forest, and the latter by the presence of a non-deciduous or evergreen broad-leaf forest with camphor laurels, camelias and tea shrubs, non-deciduous "oaks" (evergreen *Quercus* species) and *Castanopsis*, etc. This characteristic forest type is called laurisylvae or Lorbeerwaelder, and I will abbreviate it as LS in this paper. During the last interglacial period, which started about 12,000 YBP, but especially since 6,500 YBP, the LS, which had adapted to the warmer temperate climate of Japan, started to expand to the north, replacing the deciduous broadleaf forest of the cooler temperate zone. The latter is essentially similar to the European forest with many common, or vicariant, butterflies species: *Pyrgus malvae, Carterocephalus palaemon, Thymelicus leoninus; Papilio machaon; Colias palaeno, Aporia crataegi, Pieris napi, Anthocharis cardamines; Satyrium* (or *Fixsenia, Strymonidia*) *w-album, Scolitantides orion, Maculinea arionides, Lycaeides argyrognomon, Plebejus argus, Vacciniina optilete; Mellicta britomartis* (rather than *athalia*), *Argynnis paphia, Aglais urticae, Nymphalis io, Limenitis populi, Apatura metis*; *Minois dryas, Coenonympha oedippus*, and *Erebia ligea*. Today the vegetation of the northern half of Japan therefore looks essentially European, whereas that of the southern half represents the flora and fauna related to those occurring over the southern part of China, extending to Southwest China and the mid-slopes of the Himalayas. Typical representatives include a number of papilionid taxa and the satyrine genera *Lethe* and *Neope*.

Because of the old civilization of rice cultivation, the primeval forests have long been lost from virtually all of the Japanese plains and most of the lower montane areas except within certain religious sanctuaries or enclosures in the southwestern half of the mainland. The secondary growth LS is mixed with deciduous forest, most likely representing an earlier stage of succession with LS the climax. This mosaic nature of the Japanese woodlands extends at sea level to the northern tip of Honsyu, the largest island of the mainland group, because of the warm north-bound currents along both the Pacific and Japan Sea coasts. The presence of grass bamboo, *Sasa* spp., characterizes Japanese vegetation over all the country, including the northernmost island of Hokkaido, distinguishing it from the neighboring part of the Asian Continent (Northern and Northeast China, Korea, and Primorye or Amur/Ussuri).

General background of butterfly conservation in Japan

The first legislation to protect butterflies was for "Tennen Kinenbutu" or "natural monumental things" and was promulgated by the National Government in 1932 for *Panchala ganesa*, a typical LS species and a representative of the Oriental Region in Nara City. It was followed by the second in 1934 for *Spindasis takanonis* in Tottori City. This is another species representing the Oriental/African fauna, once thought to be rare, with myrmecophilous larvae from eggs laid near pine or cherry trees planted in profusion in parks and gardens. Both these protective regulations, as many others that followed, simply prohibited local collecting. However, since these species did occur in a number of other places over the southern half of Japan, collectors have turned away from the original protected areas to look for them elsewhere. After the war, increases in motor transport and pesticide spraying occurred, and apparently the original protected populations vanished without any records for an unknown period of time.

These two examples indicate that legislation that prohibits, as a protective measure, is totally ineffective and that locally limited populations will suffer extinction even in the absence of any collecting pressure. In spite of this, patterns of official "protection" have diverged little from the stereotype, and since then a large number of local populations, or species as a whole, have been designated by the National and local governments as Tennen Kinenbutu or natural monumental "things." These now amount to a total of 37 species. Although in some cases the entire habitat or ecosystem is protected, these regulations are usually not supported by financial and other arrangements for effective management. One gets the impression that the ruling bodies wish, by designating the protected object (be it the area, ecosystem, population, or species as a whole), to divert public accusations directed to their failure of providing appropriate measures for protection of declining species (of which many are vertebrates), with an excuse that they have, after all, not failed to make their best efforts. Thus, collecting becomes a scapegoat in the face of the mounting attacks and anger of the general populace. Both professional and amateur lepidopterists have complained of this lamentable situation, but have so far taken little systematic action to counter the general trend of the mass extinctions of butterflies in many places in spite of the increases of areas and species protected against collecting.

The latest efforts by scientists and lepidopterists

In recent years the Environment Agency of the Japanese government has been making an extensive survey of the status quo of the fauna and flora in Japan, but no results have been published yet. It is expected, however, that the Agency will do so by the end of 1989. Prof. Takashi Shirozu, the dean of Japanese butterfly specialists, serves as consultant for this survey.

Upon returning to Japan in 1985 after an absence of 19 years, I soon came to realize that Japanese lepidopterists were behind their colleagues in Europe and the United States in making efforts to rectify the trend of modern civilization which is rapidly endangering the butterfly fauna in Japan in addition to many other life forms. In late 1987 I made an appeal to the Lepidopterological Society of Japan on this point. It was received warmly by committee members, who then offered to organize a working group to publish volumes of collected case studies on the decline and extinction of individual butterfly populations. Japanese lepidopterists, with accumulated data and living memories, are encouraged to write case studies today. These studies would be indispensable to the future planning of butterfly conservation in Japan. In order to practically cope with rapidly changing situations, it was decided to publish certain selected cases to start with, rather than to aim at ambitious and time-consuming exhaustive surveys. The first volume of the series, entitled Decline and Conservation of Japanese Butterflies, was recently publicized under the co-editorship of Eiichi Hama in Matumoto, Nagano-ken, Minoru Ishii of the University of Osaka Prefecture (Department of Entomology of the School of Agriculture), and myself. For the present paper I have extracted much information from the manuscripts of this volume, written by a number of active field workers from various parts of Japan.

While this work was in progress, two important books on similar subjects have been published: one, by Hiroshi Moriyama (1988), a professional specialist at the National Institute for Environmental Resources, Tukuba Science City, deals with the real meaning of nature conservation. He heavily utilized butterfly material for constructing his theory, even though not a lepidopterist himself. The other has been written by Kunihiko Sei (1988), a school teacher living near Mt. Fuji, the renowned beautiful volcano west of Tokyo, where the butterfly fauna has been seriously impoverished in recent years. Publications of these two books within a short interval were quite timely, because the former is mainly concerned with woodland ecosystems, whereas the latter is concerned with those of open country. Their main conclusions, together with those of Hama *et al.* (1989), indicate the key importance of Japanese traditional agriculture and silviculture was the maintenance and well-being of a substantial part of the Japanese butterfly fauna. The pattern of biodiversity of these habitats was the result of human culture. By implication, these books also suggest how the colorful diversity of the Japanese butterfly fauna evolved and was maintained before human settlement on the archipelago.

Ironically enough, it can now be inferred that the diversity of butterflies must have repeatedly been regenerated by quasi-periodic rejuvenations of the vegetation in various habitats. Thus a dynamic succession was maintained either by human interference in natural ecosystems through the labour-intensive, energy-saving, traditional agriculture on a "human scale," or by the devastation of natural ecosystems by fire, wind and water — a paradoxical means of nature conservation. The role of collecting is also paradoxical. As long as it is not too heavily energy- or economically-intensive, collecting provides information needed for timely actions to conserve butterflies. Blind prohibition of collecting would, because of the absence of constant surveys, pave the road to mass extinctions without our being aware of what is happening. This last point is a conclusion of Hama *et al.* (1989), as well a message of this paper. I will now turn to the substance of this contention, heavily leaning on Moriyama (1988) and Sei (1988) as well as Hama *et al.* (1989).

A summary of the case histories of selected populations of Japanese species that are described in detail in Hama *et al* (1989) is given in Table 1. Each species is the object of one or more histories given in that report. Table 2 presents an assessment of the major causal agents having either positive or negative effects on population viability of the species cited in Table 1.

The role played by traditional agriculture — woodland

As mentioned above, the Japanese temperate zone may be subdivided into two parts: the northeastern cooler temperate zone where a European type of deciduous broadleaf forest thrives, with an occasional admixture of conifers (probably as the component of climax vegetation); and the southwestern warmer moist temperate zone where, unlike the Mediterranean region, LS is the adapted climax in this climate with high precipitation. Moriyama (1988) demonstrated that during the current interglacial period which started 12,000 years ago, a gradual warming of the Japanese Archipelago caused the northern advance of LS. He estimated the speed of the LS advance into the northeast around 5,000 years ago, replacing the deciduous forests. His techniques included pollen analysis and the estimation of seed dispersal helped by various animals. The results indicated that the speed of the natural forest advance was rather slow: 40 km per 1,000-1,500 years. However, local vegetation today does not represent the climax of such a LS forest. It contains, or did until 20-30 years ago, conspicuous patches of deciduous broadleaf forests or coppice, the origin and maintenance of which proved to be entirely artificial. Moriyama showed, again estimating the speed of forest spread, that these broadleaf constituents, once so characteristic of the Japanese countryside, could not have secondarily found their way down to southwest from its northeastern retreat, quite some time after the onset of the interglacial period. This means that the northeastward advance of SL during prehistoric times coincided with the beginning of primitive agriculture by the prehistoric inhabitants of the islands with slash and burn methods. This activity promoted the rapid growth of the deciduous trees, both naturally and artificially, involving relict local floral components during the vegetational transition period. Thus, some part of the flora and fauna associated with the cooler temperate forests could remain, through human interference from the very outset of the LS invasion into the warmer temperate forest zone. In fact, this deciduous association was able to remain as coppice, which generations of farmers must have used for fuel and compost (hence the origin of the word "to coppice"). The process cleared undergrowth and was reflected in the annual as well as intermittent rejuvenation of the woodland. The associated flora and fauna did not immigrate there secondarily, but remained *in situ* during all the time since the onset of the current interglacial episode. Moriyama points out that the coppice corresponds to the initial stage of arboreal succession in the warmer temperate zone.

Table 1. Summary of case studies in Hama *et al.* (1989). For numbers in the columns of subsequent processes and possible causes of decline, see Table 2; *d*, decline; *e*, extinction; *u*, unknown.

Taxon	Year		Subsequent processes	Possible causes of decline
	Extinct or (declined)	Protective actions taken on population or (species)		
Pyrgus malvae	(1982)	1975	24	26?
Carterocephalus palaemon	(1967), 1987[*1]	(1975)	24	15, 26
Luehdorfia japonica	1979			*u*[*2]
L. puziloi	(1968)	1975	10	11,26
		now proposed	10	11,13
Colias palaeno	no *d*[3]	1975	24	no evidence for 26
	(<1975)[*4]	1975	24 & *d*[5]	*u*[*6]
Aporia hippia	1966	1975	*e* before 24	20,14
Anthocharis cardamines	1978	1975	24	*u*[*7]
Artopoetes pryeri	1977			16,17,18[*8]
Coreana raphaelis	(1987 – 88)	1973	24 *d,e*[*9]	12,18,26
		1973	*e*, then 10[*10]	13,14,17
Niphanda fusca			gradual *d*	17,18
			d	17,18
Shijimiaeoides divinus	1950 – 72			13,17,18, 21,22
	1960's		6 but...	22
Tongeia fischeri	1960			27
	1961			17
	1964			27+18-19
	(1970's)			14,19
	1975			19
	(1981)		shift of habitat	6+17
	1984			11
Lycaeides subsolanus yarugatakeana	(1970)	1975	24	18+20
		1975	prone to *d*	5 but 14
Fabriciana nerippe	1963			11,13
Melitaea scotosia	1963			*u*[*11]
	(1986)		shift of habitat	13[*12]
	1983			16,17,19,20
			d	13,17,19,20
Aglais urticae		1975	24[*13]	11,12,17
Limenitis populi	1976?	1975	24	14
		1975	24[*14]	with 5,9 but *u*
Oeneis norna		1975	24[*15]	probably 21 but not 26
Oeneis melissa	(1975 – 81)	(1965)	24	26?
Erebia ligea		1975	now danger of *e*	20
E. niphonica		1975	now danger of *e*	20

*1 Isolated populations.
*2 Impoverishment of woodlands, increase of orchards, spraying, invasion of hikers, construction of a golf course are mentioned.
*3 No change of population density before and after designation as *Tennen Kinenbutu.*
*4 The population had declined prior to the designation of *Tennen Kinenbutu.*
*5 The population decline has not stopped after the designation of *Tennen Kinenbutu.*
*6 The reason may or may not be due to the putative overcollecting.
*7 Used to be an unusually large population. Foodplants are plenty after some modification of habitat due to sightseeing developments.
*8 Foodplants still remaining.
*9 Citizens' activities for protection, but population perished after the designation of *Tennen Kinenbutu.*
*10 Foodplants were planted by citizens and school children. The local government and collectors have collaborated for restoring the population. One of the model cases of conservation.
*11 Other butterflies species are intact at the habitat where this species alone disappeared.
*12 The marsh where this species thrived before has undergone modification of biotope; hence this species moved out of this habitat and found some alternative spots along cultivated areas, which are now being abandoned. The new habitats are thus being threatened of overgrowth.
*13 The habitat for larval feeding has vanished.
*14 Population number fluctuating.
*15 Population did not change before and after the designation of *Tennen Kinenbutu.*

Turning to butterflies, Moriyama indicates that *Luehdorfia japonica* (Papilionidae), the vicariant in southwest Japan of the south European *Zerynthia* (or *Parnalius*), requires, for adult feeding, early spring flowers such as *Erythronium japonicum* (Liliaceae) or violets blooming on the sunny bed of the coppice then without leaves. Its larvae require *Aristolochia,* foodplants that are generally associated with LS, with some species growing in coppice areas on the periphery of their range. After vegetational succession causes a denser woodland, *L. japonica* can no longer thrive both because of the lack of enough light for adult butterflies and of adequate food for both adults and larvae.

The coppice is now rapidly vanishing from the rural areas because of residential, industrial, and tourist developments. It is also disappearing from hilly slopes owing to the decline of traditional agriculture and forestry with their lower productivity. Presently there is little rejuvenation of the deciduous forests with abandonment of the regular felling at about 20 years' rotation cycle for charcoal production and coppicing for other purposes associated with the traditional self-sustaining rural life. Deciduous trees have been replaced either by conifer plantations or by the advance of succession in the absence of human interference. This latter process darkens the hillsides with a thick cover of vegetational growth from high precipitation. Thus, the characteristic butterfly fauna and conventional agriculture, as integral parts of the traditional Japanese culture, are quickly disappearing.

Some species of arboreal thecline lycaenids such as *Japonica saepestriata* and *Favonius yuasai* that respectively feed on *Coreana raphaelis* and on young *Quercus acutissima* or *Fraxinus* are heavily dependent on trees

Table 2. Assessment of various natural and artificial processes for their effects upon survival and conservation of butterflies. (Processes are numbered for their references in Table 1.)

Positive effects	Negative effects
1. Arrest of vegetational succession.	11. Large scale plantation of single species including conifers and other afforestation.
2. Forest fires of natural origin, typhoons.	12. Large scale felling of forests.
3. Traditional forestry: coppicing, removal of undergrowth, charcoal production, diverse plantations.	13. Decline of traditional forestry and agriculture: cessation of coppicing and grass-cutting; spraying.
4. Variation of flow rate of rivers.	14. Large scale management of water flow: inundation by dams, artificial stabilization of flow routes, technological sealing of slopes, utilization of dry river-beds for developments.
5. Naturally caused floods.	15. "Super"-forest roads (suupaa rindoo) for tourism.
	16. Drainage and other uses of marshes.
	17. Road construction and deforestation.
	18. Residential development.
	19. Industrialization.
	20. Resort and sightseeing development: opening of camping, parking, and skiing grounds.
	21. Expansion of leisure pursuits and tourism: golf courses, resort hotels.
6. Traditional agriculture: slash and burn, conversion, crop rotation, plantation, grass-cutting, animal husbandry.	22. Modern agriculture: use of mechanical power, pesticides, large-scale farming.
7. Horticulture and gardening compatible with high plant diversity.	23. Large scale gardening in artificial settings.
8. Policy of environmental protection backed up with adequate financial support.	24. Designation of *Tennen Kinenbutu* (Natural Monuments) or other prohibitions without adequate management, monitoring.
	25. Overprotection and excessive prohibition of human interference.
9. Ordinary collecting with modest intensity, surveys, observations.	26. Excessive collecting, especially of declining populations.
10. Lepidopterists' advice on protective measures and volunteer patrolling.	27. Magnifying effects of overconstruction of mountain roads, etc., on natural disasters caused by typhoons and floods.

planted by the agricultural community [Moriyama (1988) and others (see Hama *et al.*, 1989)]. Because of the decline of the traditional way of life in rural areas, those trees are now largely being eliminated. Furthermore, in the totally protected areas the native forests are permitted to grow taller and denser. Here the young growth upon which larvae depend has disappeared under the thick canopy along with their adult butterflies stages. It is now evident that traditional agriculture contributed to maintaining high biodiversity of both flora and fauna.

The role played by traditional agriculture — open lands

Meanwhile, Sei (1988) and Hama *et al.* (1989) have demonstrated that a parallel situation applies to open country including meadow, marsh, and rocky areas. Again, the traditional agriculture periodically eliminated overgrown grasses and rejuvenated diverse growth within the low vegetation. The rotation of cultivated lands also rejuvenated open land vegetation. Such customs thus artificially created diverse conditions for various open-country ecosystems. Today these practises have long been abandoned and the land is now utilized for development including housing, industry, resorts, modernized agricultural combines, and animal husbandry. Some of these developments were not even economically successful. Gone with them were characteristic open-land butterfly fauna including *Shijimiaeoides divinus*, *Tongeia fischeri* (Lycaenidae, Polyommatini), *Phoebe scotosia* and *Fabriciana nerippe* (Nymphalidae). Sei (1988) pointed out that a river, because of variation of its gradient and hence the velocity of the flow, along its path diversifies the physical conditions of the bank and encompassed ecosystem and thus maintains the diversity of butterfly fauna across the surrounding open lands. According to Hama *et al.* (1989), the vegetation along a river is vulnerable to flooding, yet would regenerate quickly, thus contributing to the dynamic maintenance of flora and fauna. Current construction technology for water flows to prevent landslides and floods and the development of river banks for modified land use destroys, or at best simplifies, ecosystems of the bank and stabilizes a river's route. Coupled with the decline of traditional agriculture, the diverse habitats of open lands are lost, resulting in the local extinction of many open country species of butterflies. Thus, prior to the human intervention, heavy rainfall with resultant floods and devastating typhoons, along with natural forest fires, played a critical role in maintaining the diversity of butterfly habitats in wilderness. The advent of agriculture probably did not threaten this diversity, largely because it contributed to diversifying the ecosystem. Only when combined with extensive human interference resulting in the extensive disappearance of woodland could those natural disasters produce irreparable damage to the local ecosystems.

Other factors including collecting

Apparently, however, not all factors explaining butterfly extinction are classified. Hama *et al.* (1989) present two examples in which the reasons for extinction could not be identified. In both cases land was modified without a decline in the food plants, yet subalpine *Anthocharis cardamines* (Pieridae) became extinct and other butterfly species associated with *Melitaea scotosia* in the same grassland habitat declined as well. As for the effect of collecting on the population of alpine butterflies, there are two opposite views expressed in Hama *et al.* (1989). In the central highlands of Honsyu, *Oeneis norna* (Nymphalidae, Satyrinae) has not declined in the alpine area and did not show any change in population density before and after the 1975 prohibition of collecting. However, in small isolated montane areas in Hokkaido, *Oeneis melissa* and *Pyrgus malvae* (Hesperiidae) (both protected species) suddenly started to decline during 1975-1982. Illegal overcollecting is the suspected cause, although there is no clear-cut evidence.

Comparison with other countries

In urban areas, butterflies are not scarce, but their diversity is always substantially lower than in nearby natural areas. In this regard, the current Japanese scene may be comparable to Sydney, Australia (1985) and Khabarovsk in the Far East USSR (1988), where I found ordinary butterflies to be numerous in parks and gardens. However, my observations in Seoul, Korea (1984 and 1986), and Beijing and Kunming in the People's Republic of China (1988) indicate that butterflies were quite scarce in urban and extended agricultural areas while they were fairly abundant in woodlands. These crude observations may be related to spraying insecticides, but I have no hard data.

I wish to add that several species endangered in some parts of Europe have not so far showed signs of decline in Japan. Such species include *Papilio machaon* (still a pest in home gardens), *Minois dryas* and *Coenonympha oedippus* .

Strategy for protection and conservation

Butterflies are organisms. They are not simply "things" to be protected as archaeological or artistic objects and cannot be maintained as such. They represent life processes. It is thus fundamentally wrong to protect them as tangible objects. Continuing population maintenance requires dynamic processes. The centerpiece of a dynamic system requires constant attention and monitoring. In today's society this means money. To designate a population or species of butterfly or an area to be protected is meaningless unless supported by budgetary action. This includes defending the habitat against invasions by exotic competitors, constant management using traditional agriculture or forestry practise as a model, and monitoring and ranging activities. We urge Japanese authorities to consider these points. At the same time, the trend of establishing green zones in urban areas should be directed towards restoring ecosystems native to these areas. Human residences should be rearranged and removed from some larger habitat areas, simply because commensal animals as sparrows and rodents might be factors affecting some sensitive species. A large effort in politics and education are needed from butterfly specialists and collectors alike.

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